AD NUMBER

AD149442

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TO

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AUTHORITY

HDL D/A ltr, 15 Aug 1979

AD NUMBER

AD149442

CLASSIFICATION CHANGES

TO

confidential

FROM

secret

AUTHORITY

31 Dec 1960, DoDD 5200.10

A SENSING SYSTEM FOR DYNAMIC ARMOR

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INTRODUCTION

Passive armor has been used as a defense through the centuries ever since the Stone Age. It has finally lost the race against attack weapons with the invention of high-penetration rounds of the kinetic energy and the shaped charge type. As these rounds have a penetrating power of 10 and more inches of steel, a tank carrying sufficient armor to stand up to them would no longer be acceptable by considerations of weight, maneuverability and air-transportability.

A promising tank defense against high-penetration rounds consists of equipment that intercepts and defeats the attacking round by a high-velocity defending round. This is the principle of what is now called Dynamic Armor.

Credit for the basic idea is due to Picatinny Arsenal. Technical responsibility for the over-all project rests with Detroit Arsenal. Picatinny Arsenal takes care of the development of the defending charges, and the Diamond Ordnance Fuze Laboratories are in charge of the sensing system.

DESCRIPTION OF DYNAMIC ARMOR

The system presently under investigation at DOFL is an optical one. It employs infrared-optical sensing screens which detect the approach of anti-tank rounds, and an electronic computer which measures velocity, direction and height of attack, computes the firing time, and generates a firing pulse to detonate a linear shaped charge on the tank in the right position and at the right time to defeat the round.

The sensing system, figure 1, consists of three optical screens body and the [illegible] size increases considerably as the altitude of the missile [illegible].

It is [illegible] under the present operation to take measurements from [illegible] miles [illegible] and possibly at even greater ranges depending on [illegible] results [illegible] at 300 miles. At the present time, an [illegible] is being [illegible] to design an electrical and mechanical system to gain better contrast between target and background. One method is through the use of filters. The U.S. Army White Sands Signal Agency is now designing filters which, when completed, will allow detection and tracking equipment to operate in daylight against missiles of IRBM class at ranges of 500 miles or more. Later it is anticipated that measurements will be made utilizing several spectrometers and other instruments including lead telluride detection cells in order to learn more about the various flame characteristics of many different types of missiles and missile propellants and the advantage obtained through use of airborne detection devices.

1, 2, and 3, which originate at the tank wall, 4, where a suitable number of defending linear shaped charges, 5, is also located. Two of the screens, 1 and 2, are parallel, while the third, 3, makes an angle with the other two. Each screen is made up of numerous, parallel sensing elements, each of which is a composite of two columns, an illuminating beam and a detecting channel, adjacent and parallel to one another. Each pair of these columns originates at a sensing unit which consists of two small parabolic reflectors, 6 and 7, that have a light bulb and a light detector respectively at their focal points, figure 2. Near infrared filters over the light bulbs cut out all visible light. The detectors that are presently used for the experimental work are PbS cells. Three rows of sensing units making suitable angles with the vertical and with suitable spacing between one another will be lined up along the periphery of the tank.

OPERATION OF DYNAMIC ARMOR

An oncoming round, 8, figure 1, traverses at least one sensing element in each of the three optical screens at points 9, 10, and 11. It intercepts in each of them the light of the illuminating beam and reflects a portion of it back to the detector at the base of the detecting channel. In this manner, at least one detector in each of the screens is alerted.

The positions in space of the traversed beams are known from the design data. The transit times for the round to move from a sensing element in the first screen, 1, to those in the two following screens 2 and 3, are measured by the computer system as time differentials between electric pulses that are caused by alerting the first and the two consecutive detectors. From these time differentials, from the design data, and from the known fragment velocity of the defending charge, the computer will select a defending charge, 12, which is in the right position, and generate a firing pulse at the right time so that the defending charge fragments and the round arrive at the same point, 13, at the same time.

A computer is under construction that can be expected to accomplish this for rounds which approach in directions up to 60° from the tank wall vertical at velocities from 200 to 5000 ft/sec and elevations from about one-half to 5 ft.

RESULTS

Experiments have been made at DOFL with a simplified arrangement, figure 3, that consisted of one vertical slice only of the described system; that is, of only three sensing beams, one out of each of the three screens. This set-up was used to record pulses from 4" diam. simulated missiles which were fired from an air gun with velocities from 200 to 1000 ft/sec, and from 75 mm inert artillery rounds which were fired at the DOFL Test Area with velocities from 1400 to 2600 ft/sec.

Figure 4 shows a typical oscillogram, with the round coming in from the right. The lower trace records the two pulses from the passage of the round through the first and the third optical screen; in the middle trace is the pulse due to the round going through the second screen which is parallel to the first. The two pulses in the upper trace are caused by the round making contacts in two double aluminum foil screens which were placed in the trajectory at a known spacing.

The time differential between the first pulse in the lower trace and the one in the middle trace, and that between the two pulses in the upper trace made possible two independent determinations of the same velocity. Both checked within a few per cent for all velocities used.

In addition to the velocity, one can also determine the elevation of the trajectory, that is, its distance from the apex of two diverging screens, if one compares the time differential from the two diverging screens with that from the parallel screens. Determinations so made also checked with direct measurements of that distance. From the velocity and distance obtained in this way, the computer determines the firing time of the defending charge.

That the spatial resolution is sufficient to provide accurate enough information to the computer for the selection of the right defending charge to be fired was proven with an experimental set-up of three slices; that is, of nine sensing beams.

OTHER CONSIDERATIONS

The Dynamic Armor System must not respond to accompanying personnel moving near-by, to variations in ground reflectivity, moving clouds or overhanging tree branches. To this effect, high-pass electrical filters that only transmit frequencies above about 200 cycles/second will be used.

In a tank that is equipped with Dynamic Armor, it will not be desirable to waste any defending charges on small-arms fire, while rounds above a certain caliber should be safely defeated. This condition can be fulfilled (1) by arranging the sensing beams at such a spacing that no large-caliber round can slip through unnoticed, (2) by setting up an additional condition that at least two adjacent sensing elements in each screen have to be alerted in order to alert the computer, so that small arms bullets which pass only one sensing element will not be noticed, and (3) by leaving on the tank some residual armor, only about 1-1/2 inch thick, that will defeat small-arms fire.

CONCLUSION

There remains in this project a great number of problems that have yet to be solved. But, if Dynamic Armor can be completed successfully, the Army will be provided with a tank which may be heavily armed, and may be so light in weight that it can be transported by air.

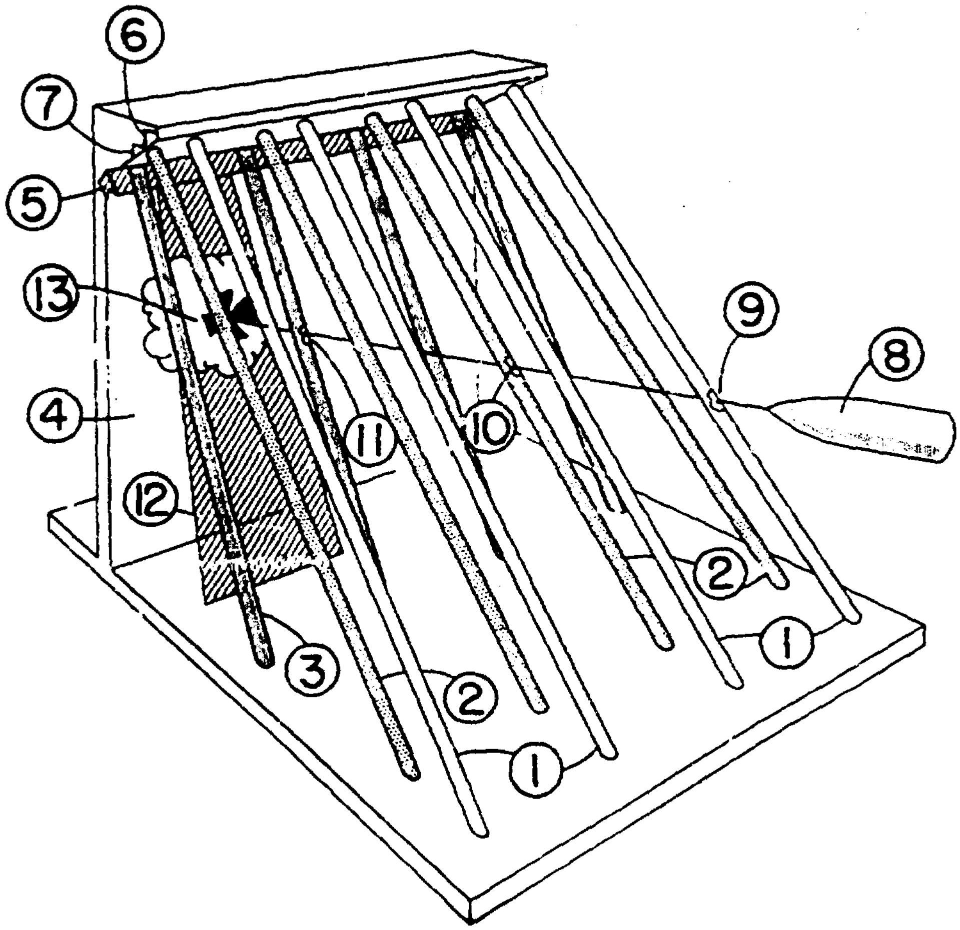

Figure 1. Diagram of dynamic armor sensing system.

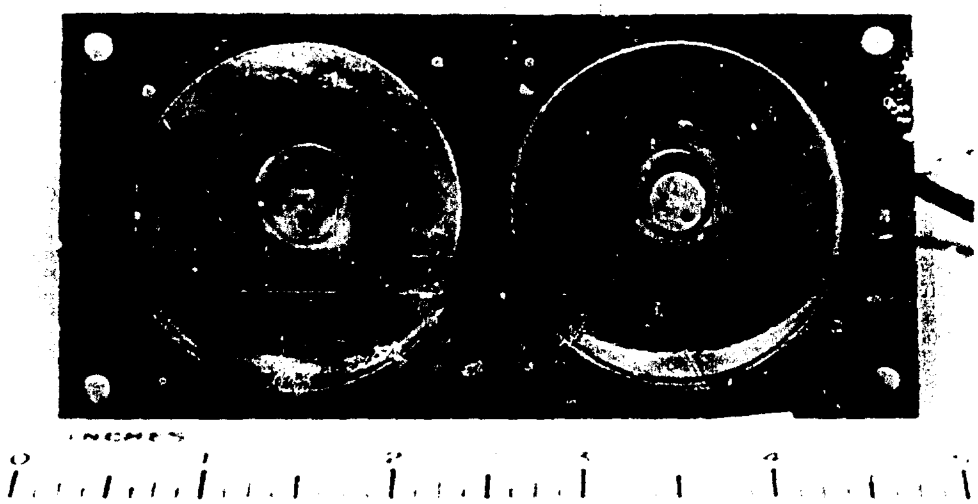

Figure 2. Sensing unit.

Figure 2

Figure 3. One slice system mounted over airgun.

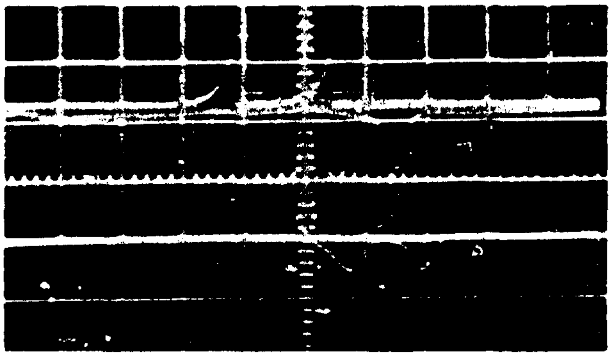

Figure 4. Typical Oscillogram.

Figure 4

STUHLINGER

POTENTIAL CONTRIBUTION TO THE EARTH SATELLITE PROJECT
BY THE
ARMY BALLISTIC MISSILE AGENCY AND THE JET PROPULSION LABORATORY

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This paper intends to show how a satellite project could be implemented as a natural outgrowth of missile projects which are presently underway at the Army Ballistic Missile Agency at Huntsville. This satellite project, if it should be activated, would by no means constitute a replacement of the existing VANGUARD Satellite Project. It should be considered as a part of the VANGUARD Project, a kind of [illegible] to the real VANGUARD, which would give our country an [illegible] satellite capability than the VANGUARD Project may be able to give. The first one or two satellites would provide data [illegible] the oblateness of the earth, the [illegible] the state of ionization of upper atmospheric layers [illegible]. Further satellites, if so desired, could carry practically all the [illegible] instruments which are now scheduled for VANGUARD satellites.

Members of the present Army Ballistic Missile Agency at Huntsville, formerly of the Guided Missile Development Division at Redstone Arsenal, have been engaged in theoretical investigations of satellite projects for many years. The possibility of building and launching a small satellite as part of the development work assigned to that group became apparent in 1954. In September of that year, Dr. von Braun wrote a memorandum in which he pointed out that a small satellite could be successfully launched with missiles and other components which existed at that time. The proposal was based on the REDSTONE High Altitude [illegible], A REDSTONE Missile with slightly elongated tanks, a lighter [illegible], and a simplified control system. Two missiles of that type, [illegible] and 29, had been set aside in April 1954, for special tests. The upper stages of solid propellant rockets, in combination with the REDSTONE booster, were found capable of orbiting a payload of several pounds. A number of studies on performances, orbits, lifetimes, tracking, instrumentation, and staging, supported the proposal.